Physics 196 Lab 6: Series and Parallel Resistor Circuits

Equipment:

Vernier Circuit Board, Lamp Bulbs (3 of the long, low voltage lamps), Alligator Lead Set, 2 D cell batteries for Vernier VCB, Blue Digital Multimeter for current (BK Precision), Leads for Blue Digital Multimeter (R/B), Orange Digital Multimeter for Voltage (Extech), Probes for Orange Multimeter (R/B).

Layouts:

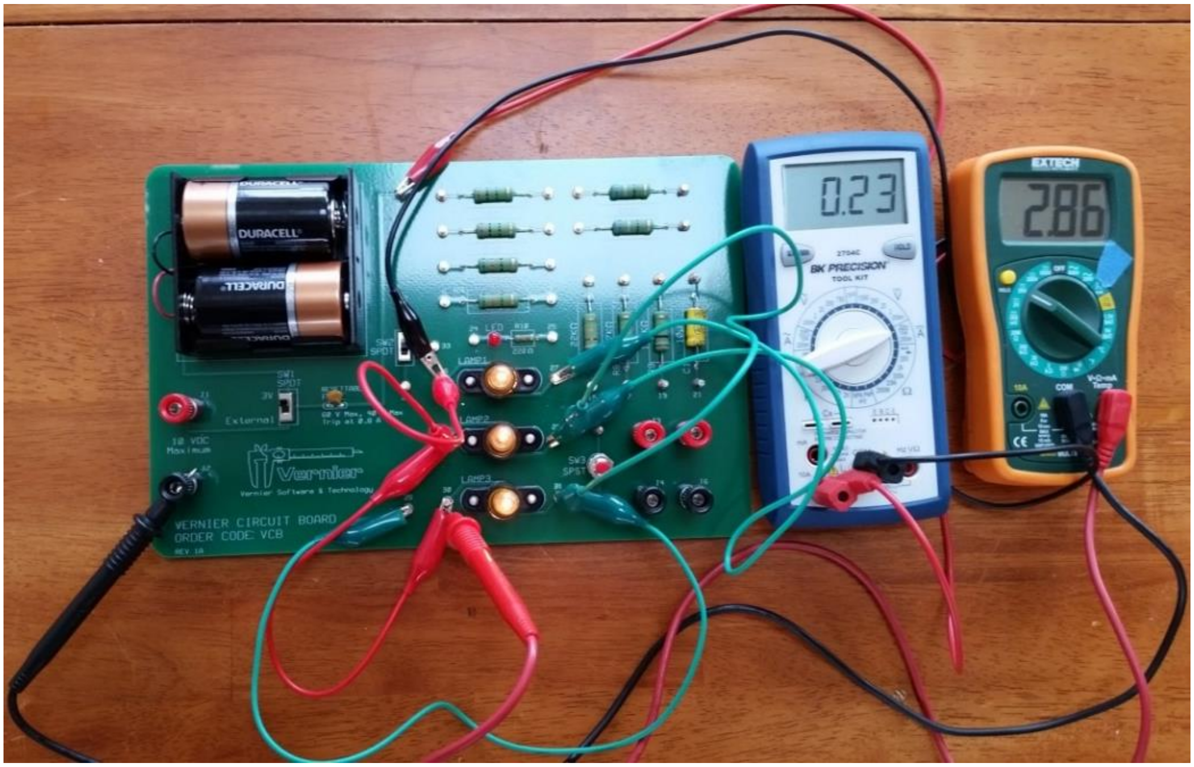


Figure 1: Equipment for Lab 6, Series and Parallel Resistor Circuits

Summary:

Students will work in teams of three, using digital multi-meters to measure voltage and current at various locations in circuits consisting of a voltage source, one or more lamps and one or more resistors. The equipment is shown in figure 1. For this lab, the source of voltage will be two D cell batteries. Current is measured in series with the circuit element(s) through which the current is flowing using the Blue BK Precision multi-meter on the 10A DC setting, with the red (positive) lead connected to the 10A connector on the meter and the black (negative) lead connected to the COM (common) connector on the meter. (Since the meter is in series with the circuit element(s), the same current flows through both the circuit element(s) and the meter. There is a small voltage drop due to the resistance of the meter). Voltage is measured in parallel with the circuit element(s) through which the current is flowing using the orange Extech multi-meter on the 20V DC setting, with the red (positive) lead connected to the V-Ω-mA connector on the meter and the black (negative) lead connected to the COM (common) connector on the meter. Since the meter has a very high internal resistance, it should have very little impact on the voltage measurements. The negative (black) voltage meter probe can be connected to the (-) trace on the circuit board at terminal J2 for the whole experiment, defining a circuit ground at 0V DC. The circuits can be turned on and off (that is, connected to or disconnected from the 3V battery source) using switch SW1.

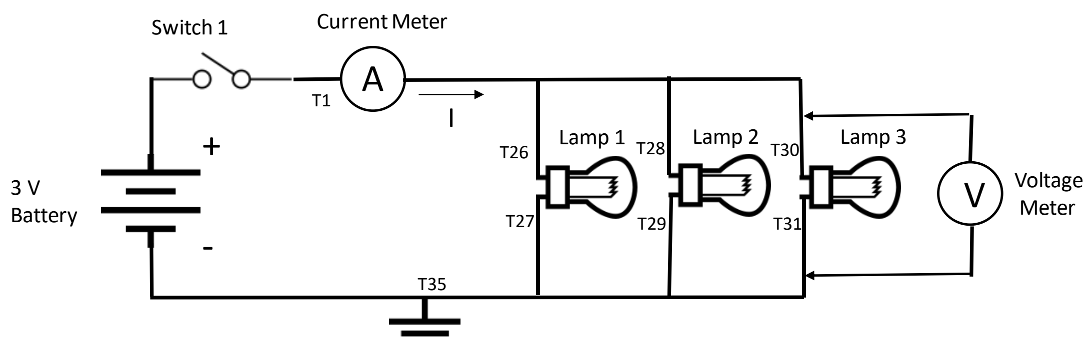
Prelab: Tape the first page of the write-up, including Materals, Layout and Summary in your notebook. Look up formulas for the equivalent resistance of resistors in series and parallel, and write them down in your lab notebook. Draw circuit diagrams for the resistor configurations in Experiments 6,7,8 and 9 and calculate what you expect to measure for current and voltage at various locations in the circuits, and calculate what you expect the equivalent resistance of the circuits to be. (Remember Ohm's Law, V=IR, from last week).

Lab: Carefully lay out the equipment on the lab bench. Insert the D cell batteries in the circuit board. Insert three of the long (lower voltage) light bulbs into the lamp sockets. **For all of the experiments, draw circuit diagrams in your notebooks, showing battery, lamps or resistors with proper symbols, switches, wiring, terminal numbers, and measurement locations.**

Experiment 1: Light bulbs in parallel.

a) Hook up Lamp 1 in series with the current meter, turn on Switch 1, measure and record the voltage across lamp 1 and the current through it, and observe its brightness. Turn off Switch 1.
b) Hook up Lamp 2 in parallel with Lamp 1, turn on Switch 1, measure and record the voltage across the pair of lamps and the current through the pair of lamps, and observe their brightness. Turn off Switch 1.
c) Hook up Lamp 3 in parallel with Lamp 1 and 2, turn on Switch 1, measure and record the voltage across the combination of 3 lamps and the current through the combination of 3 lamps, and observe their brightness. Turn off Switch 1.

What changed in going from a) to b) to c)? What stayed the same?
Example circuit diagram for Experiment 1c:

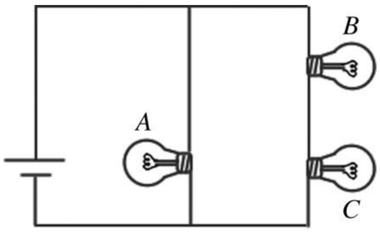


Have the instructor sign off on your circuit diagrams at this point before proceeding.

Experiment 2: Light bulbs in series.

Hook three lamps in series with the current meter. Measure the current through the configuration, and the voltage at each junction. (Top of lamp 1, between lamps 1 and 2, between lamps 2 and 3, bottom of lamp 3). How does the brightness compare to the brightness of a single lamp? How does the voltage change as a function of location? How does the current compare to that measured in experiment 1?

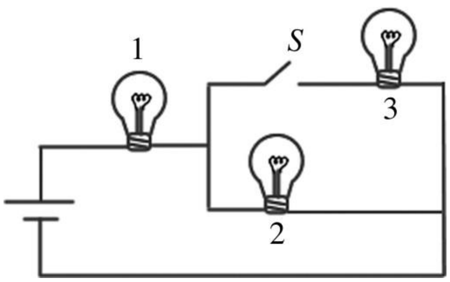
Experiment 3: Relative brightness. (There will be a question on this configuration on Quiz 6).
(You don't need to measure current for this experiment).



Hook up the battery and light bulbs so that light bulb 1 has the full battery voltage across it, but light bulbs 2 and 3 are in series with each other, but in parallel with light bulb 1. (Like in diagram)
How does the brightness of Lamp 1 (A) compare to the brightness of Lamps 2 and 3 (B and C)? What do you think the voltage is at the location between lamps 2 and 3 (B and C)? Measure it to see if you are right. Is the current through Lamp 1 different from the current through lamps 2 and 3?

Experiment 4: Change in brightness with switch: Think about the answer to the following quiz question.

The figure shows three identical lightbulbs connected to a battery having a constant voltage across its terminals. What happens to the brightness of lightbulb 1 when the switch *S* is closed?



A) The brightness will increase momentarily then return to its previous level.
B) The brightness increases permanently.
C) The brightness will decrease momentarily then return to its previous level.
D) The brightness remains the same as before the switch is closed.
E) The brightness decreases permanently.

Hook up Lamps 1, 2 and 3 with Switch 2 or Push Button Switch 3 and see if you were right. (With red push button switch, hold down to close switch and observe all of the lamps).

Experiment 5: Light Emitting Diode directional current: Just hook up Lamp 1 to the battery with +3V on terminal 26 and 0V on terminal 27. Observe the brightness. Now reverse the voltages so +3V is on terminal 27 and 0V is on terminal 26 and observe the brightness. It should be the same as before. (A resistor or lamp behaves the same way no matter which way the current flows through it). Now do the same experiment using the LED/resistor combination between terminals 24 and 25. Which way does it have to be hooked up so that the LED glows? A Light Emitting Diode is a semiconductor device which only allows current to flow through it in one direction (at least with the battery voltage used here).

Experiment 6: Resistors in Series: Hook up 10Ω Resistor 1 in series with the Current Meter. Measure the voltage across and the current through this resistor, and verify that V=IR. Now hook 10Ω Resistor 2 in series with Resistor 1. Measure the current through the combination, and the voltage above Resistor 1 and between Resistor 1 and 2. Is the Voltage drop across each resistor the same? Calculate the equivalent resistance of the two resistors in series. Measure V and I for the combination, calculate R from V/I, and compare to your calculation.

Experiment 7: Resistors in Parallel: Hook up 51Ω Resistor 3 in Parallel with 51Ω Resistor 4. Measure the current through the combination and the Voltage across it. Calculate the equivalent resistance of the two resistors in parallel, and compare to your measured value derived from V/I.

Experiment 8: Continuity of Current: Hook up 10Ω Resistor 1 in Series with 68Ω Resistor 5. Measure the current through each resistor (by hooking the current meter in different locations of the circuit) to verify that it is the same.

Experiment 9: Conservation of Current: Hook up 51Ω Resistor 3 in Parallel with 68Ω Resistor 5. Measure the current through each resistor path, and the current through the combination. (Both resistors should be hooked up for all measurements). Do the currents through the two resistors add up to the total? How does the ratio of the two currents compare to the ratio of the two Resistances?

Have fun, and try to get a good understanding of the equivalent resistance of resistors in series and parallel. Be sure to write a complete description of the experiments in your lab notebook, including labelled circuit diagrams, procedures, results and conclusions.